# The Battle Against Bots

## Current Threats and New Directions to Counter Automated Attacks

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Global Security Operations

# Who am I

- Security Researcher in the **Global Security Operations** of Amadeus
  - Protection of web domains linked to the travel industry
- Expertise in **Network** and **Application** Security
- Work based on Ph.D. and current research and collaborations

EURECOM
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جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

Resilient Computing and Cybersecurity Center

SORBONNE UNIVERSITÉ

UNIVERSITY OF TWENTE.

TELECOM SudParis

IP PARIS

**RESCUE – Resilient Cloud for Europe**
**IPCEI – Germany**
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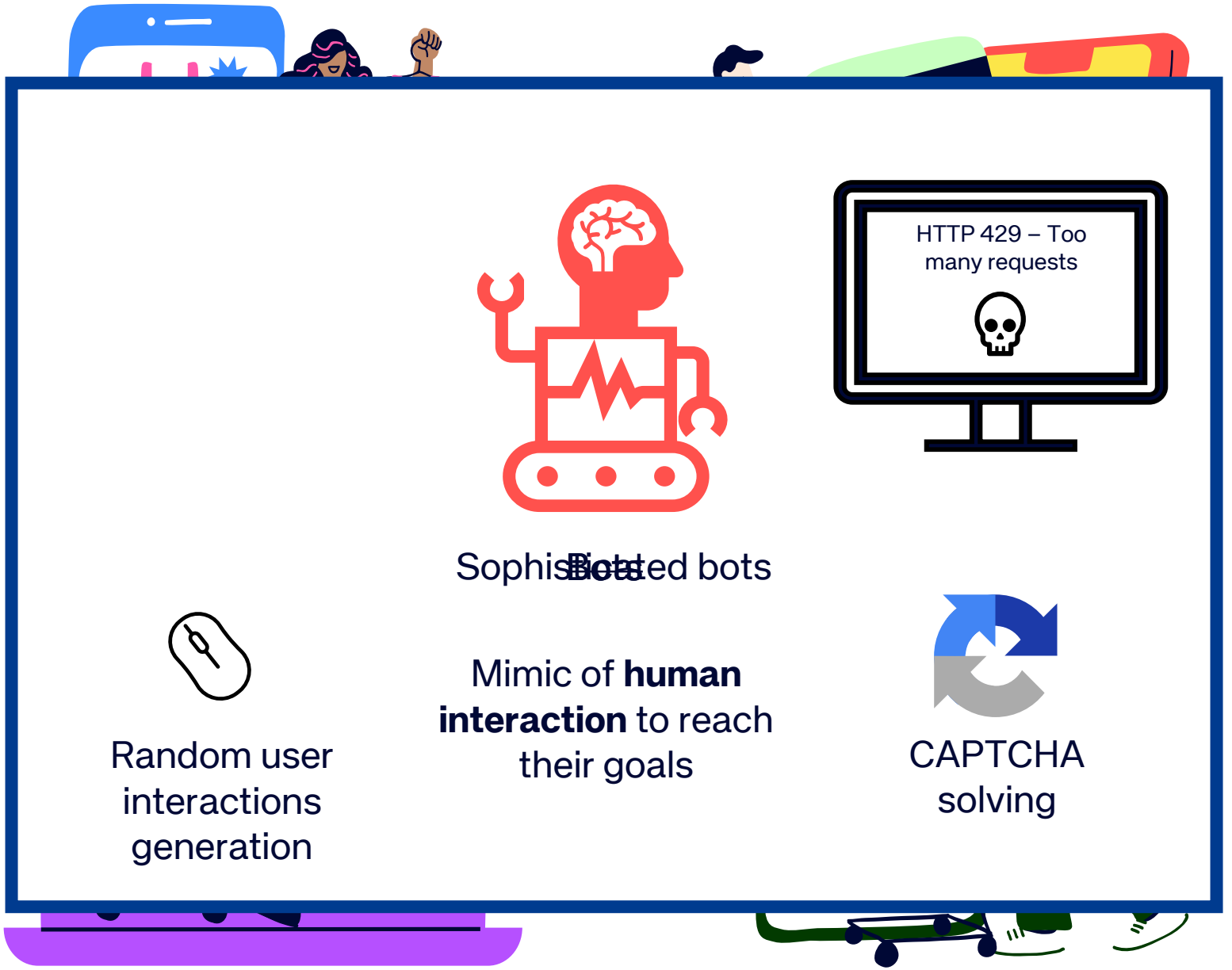


# Sophisticated Bot Attacks – Functional Abuse


## Web scraping

Competitor Monitoring

Content Reselling

Illicit Aggregators

Requests

Purchases

Revenues

Slow connections


## Denial Of Inventory

Disrupt supply and demand

Holding cheapest fares

Impact revenues and operations

Defeat the competition

Requests

Purchases

Revenues

Reputation


## SMS Pumping

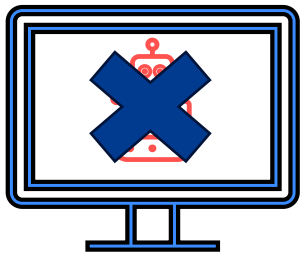
Impact revenues

Generate revenue through network operators

Revenues

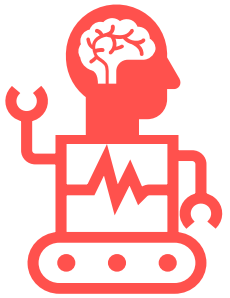
Reputation

# Arms race



New server-side bot detection technique

New bot detection circumvention technique



# What can we do?

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# Problems in current landscape

Large usage of Residential Proxies

Redirection of CAPTCHA tests to CAPTCHA Farms

Realistic fingerprints fast rotation

Side effects of current mitigation techniques reveal detection



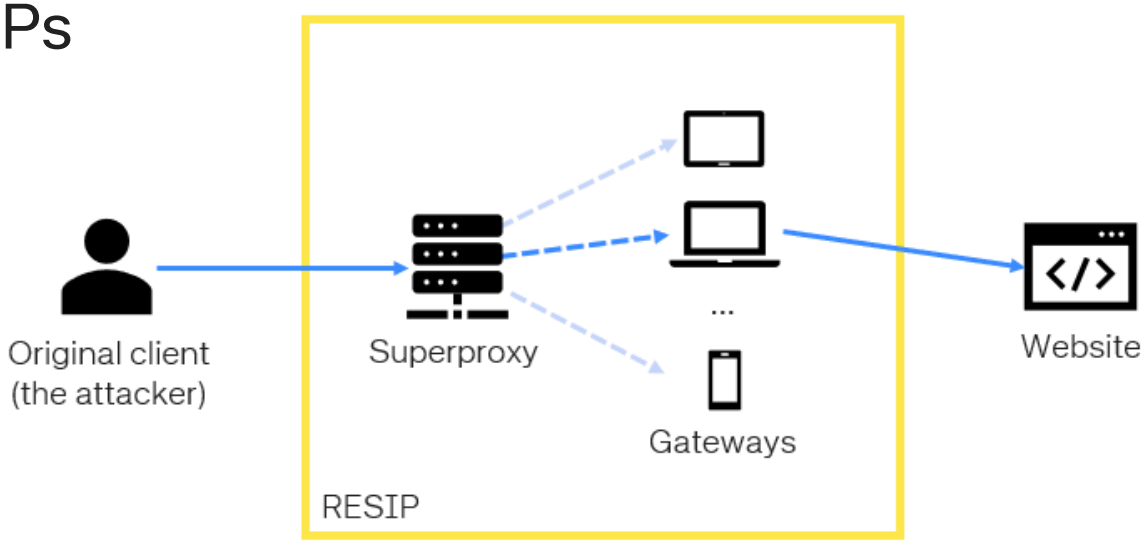


[1] E. Chiapponi (2023). Detecting and Mitigating the New Generation of Scraping Bots. In Ph.D. Dissertation, Sorbonné Université, Cryptography and Security.

# Large usage of Residential Proxies

## The problem

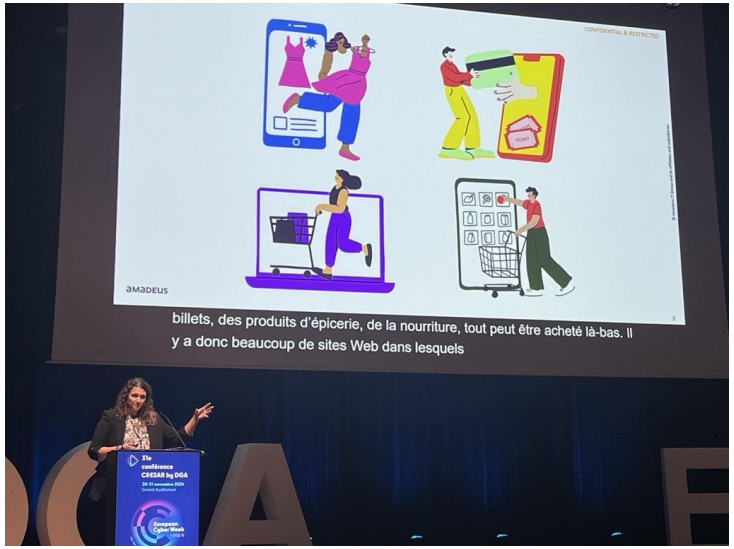
- Large networks of **residential devices** (smartphones, laptops, tablets,...)
- Devices **owned** by genuine users who **share** their usage
- No application layer information about being proxied
  - **Indistinguishable** from the requests sent directly by the residential devices at this layer
  - **High probability of false positives** for the traditional server-side bot detection techniques
- Advanced bot traffic **heavily rely** on RESIPs
- Anyone can build sophisticated bots:
  - Automated **CAPTCHA Solving**
  - Automated **fingerprint rotation**



# Large usage of Residential Proxies

## Our approach

- Study of Residential Proxies (RESIPs) **infrastructure**
  - Identification of **transport layer differences** among direct and proxied connection
  - Leverage of these difference to have two techniques to **detect server-side their usage**
- **Know better** your adversary and **raise awareness** among network operators
  - Testbed to **act as a RESIP gateway**
  - **First study** the **encrypted** traffic the proxied out

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[3] E. Khan et al. (2024) A First Look at User-Installed Residential Proxies From a Network Operator's Perspective. In CNSM 2024

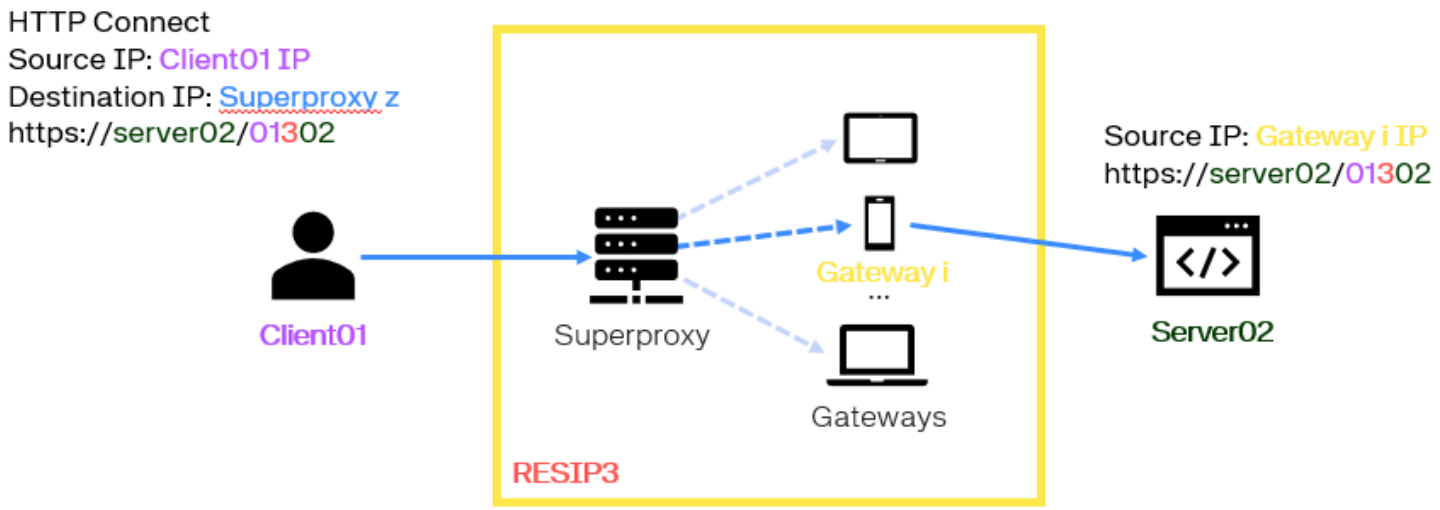
# Large usage of Residential Proxies

## Our approach

- **Arms race** and **limitations** in the techniques
  - We need to **anticipate** the next steps and keep **complementing** our detection
- Keep **studying** the traffic RESIPs proxy out from the testbed
  - Collect **more proofs** of malicious activities
  - Possible find evidence of malicious activity in the **not encrypted traffic**
- Can we know more about the **devices** and the **IPs** in these networks?

# RTT Dataset

- **4** months collection
- **4** RESIP providers
- **2 client/server** machines in **11 locations** in the world
- Requests from each client to each server through **each RESIP network**
- **69M+** RESIP connection








[4] E. Chiapponi et al. (2023). Inside Residential IP Proxies: Lessons Learned from Large Measurement Campaigns. In WTMC 2023.

# Gateways Assignation

1. **Minimization** of gateway IP **repetitions** in a **single client-server path** but not on among all paths

| RESIP | # connections | # countries | # /32 | # /24 | # /16 | # /8 | # ASes | Repeated IPs | Repeated IPs per server | Repeated IPs per client |
|---|---|---|---|---|---|---|---|---|---|---|
| BR | 2,413,405 | 226 | 1,546,886 | 712,274 | 23,274 | 193 | 17,026 | 31% | 3±1.6% | 3.3±1.8% |
| OL | 22,387,788 | 226 | 6,660,452 | 846,165 | 15,230 | 194 | 19,370 | 49% | 16.3%±0.5% | 16.3%±1.3% |
| PR | 22,523,876 | 234 | 3,982,149 | 411,949 | 14,145 | 201 | 9,871 | 61% | 23% | 23.4%±0.2% |
| SM | 22,353,578 | 224 | 6,852,898 | 859,946 | 15,288 | 194 | 19,501 | 49% | 15.7±0.4% | 15.7%±0.4% |





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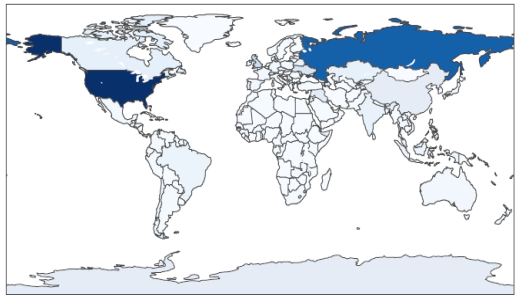
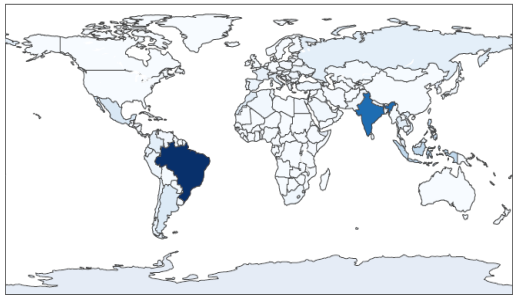
# Machines distribution

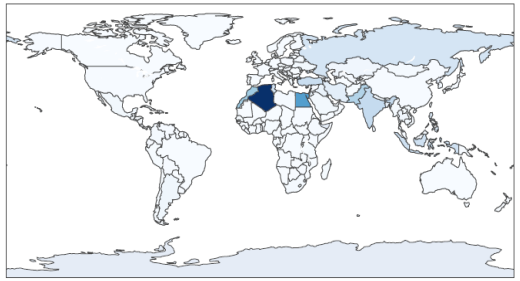
## 2. **Similar gateways geographical** distribution for two providers



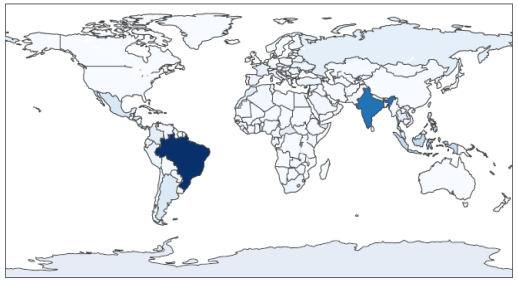
Bright Data



Oxylabs



Proxyrack



Smartproxy

## 3. **Shared IP Pool** among providers

| | BR | OL | PR | SP |
|---|---|---|---|---|
| BR | - | 9% | 5% | 9% |
| OL | 2% | - | 8% | 63% |
| PR | 2% | 13% | - | 13% |
| SP | 2% | 61% | 7% | - |



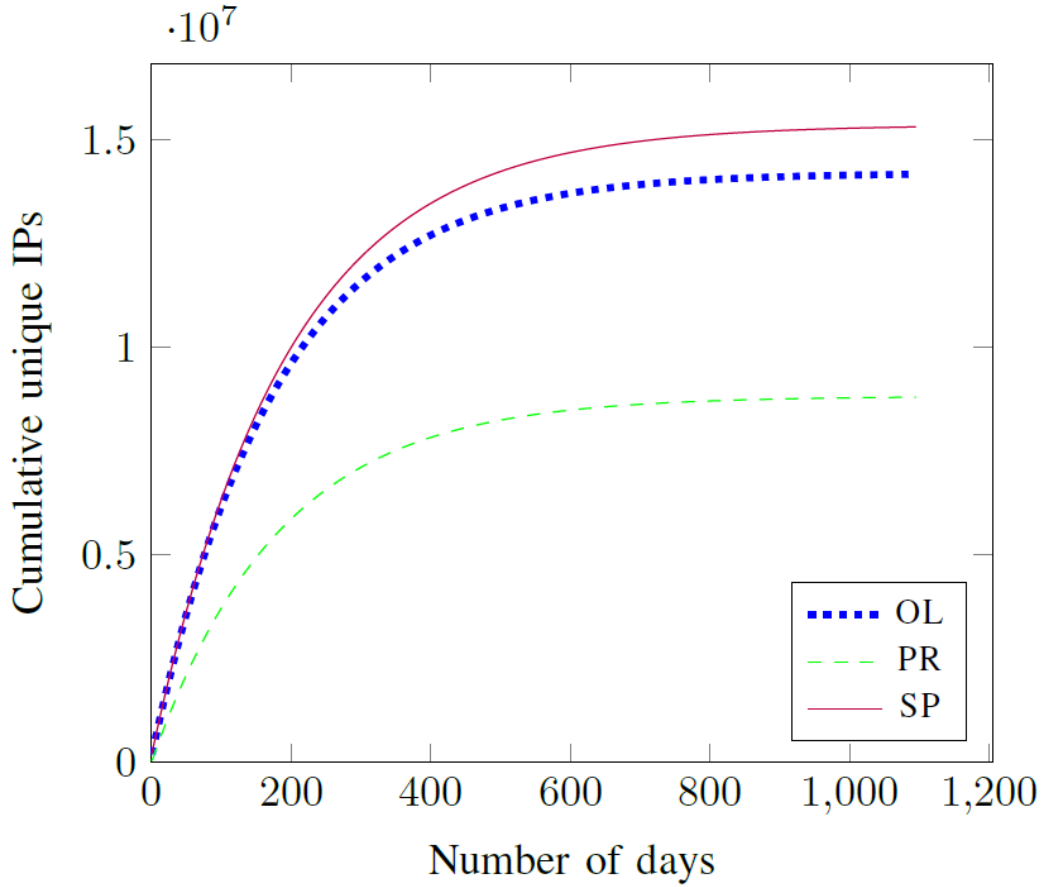
[4] E. Chiapponi et al. (2023). Inside Residential IP Proxies: Lessons Learned from Large Measurement Campaigns. In WTMC 2023.

# Amount of machines

4. Advertised IP pool sizes **do not match** our observation and projections

Assumptions:

- **Constant rate** of devices entering and exiting the network
- **No 1-1 correspondence** between the # of devices and #of IP addresses
  - Generally, **overestimation**
- **Upper bound** for the number of devices





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# External RESIP dataset comparison [1/2]

- External DS 1:
  - May 2017 - March 2018 (vs Jan 2022 – May 2022)
  - 6,419,987 RESIP IPs from 5 RESIP providers
- Sharing two RESIP providers with our study, BrightData and Proxyrack

| DB | IP repetition | IP repetition BD | IP repetition PR |
|---|---|---|---|
| RTT DS | 2.87 % | 2.52 % | 1.26 % |
| External DS 1 | 6.26 % | 0.97 % | 5.86 % |

| DB | /24 repetition | /24 repetition BD | /24 repetition PR |
|---|---|---|---|
| RTT DB | 46.04 % | 33.17 % | 29.15 % |
| External DS 1 | 45.52 % | 19.96 % | 34.74 % |





External DS: https://rpaas.site/

# External RESIP dataset comparison [2/2]

- External DS 2:
  - April 2021 - October 2021 (vs Jan  2022 – May 2022)
  - 9,077,278  Chinese RESIP IPs from 6 RESIP providers

| DB | IP repetition |
|---|---|
| RTT DS | 5.22 % |
| External DS 2 | 8.04 % |

| DB | /24 repetition |
|---|---|
| RTT DB | 54.33 % |
| External DS 2 | 58.52 % |

# What did we learn about the IPs

- Each provider **reuses** IPs among different paths (and possibly users)
- Different providers **share** pools of IPs
- The total amount of RESIP IPs is **smaller** than advertise values
- IP changes, **/24 vary less**
- Can we **leverage** this information?
  - **Tracking /24** and associate the ones where RESIPs appear to a **risk score**
  - Genuine users **share** their devices -> **Whitelisting** to reduce FPs
    - Association of IPs completing a **confirmed human action** (e.g. booking) to the corresponding **fingerprint**
- **Next step:** track the **coverage** with the RESIP IPs detected in Amadeus + complement with study of **number of devices** (Böck, L. et all. (2023). How to Count Bots in Longitudinal Datasets of IP Addresses. 10.14722/ndss.2023.24002.)

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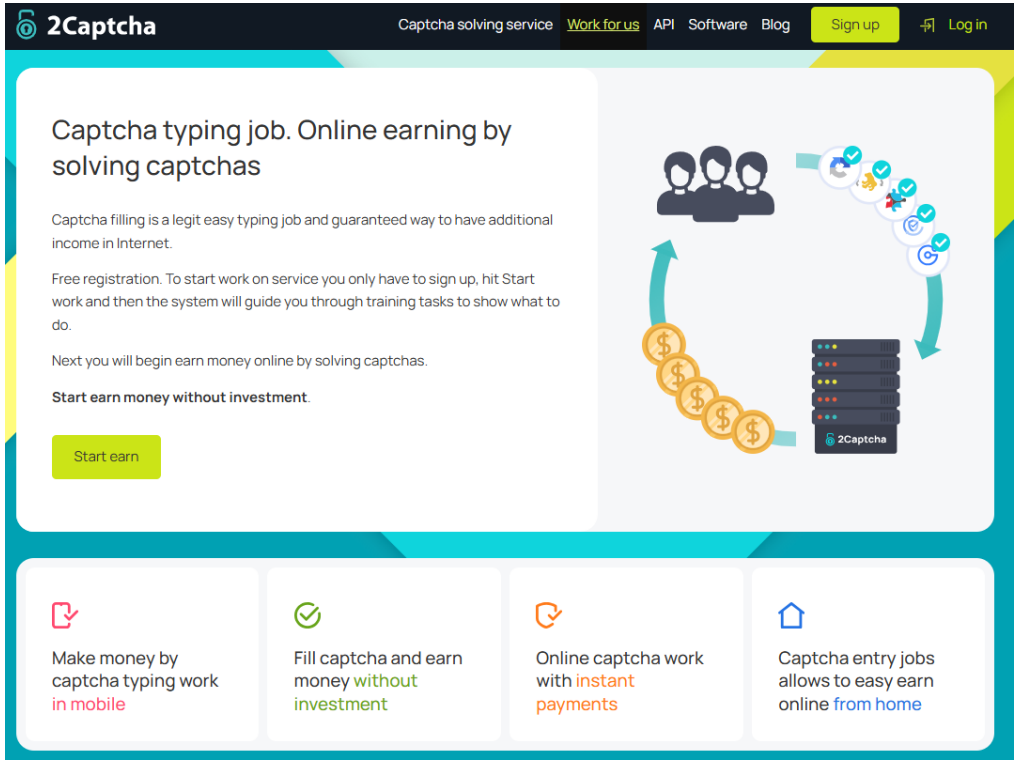
# Redirection of CAPTCHA tests to CAPTCHA Farms

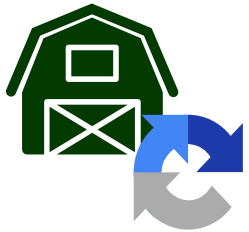
## The problem

- CAPTCHA Farms are **virtual or physical** realities where people are paid to solve CAPTCHA tests **redirected to them**



# Redirection of CAPTCHA tests to CAPTCHA Farms

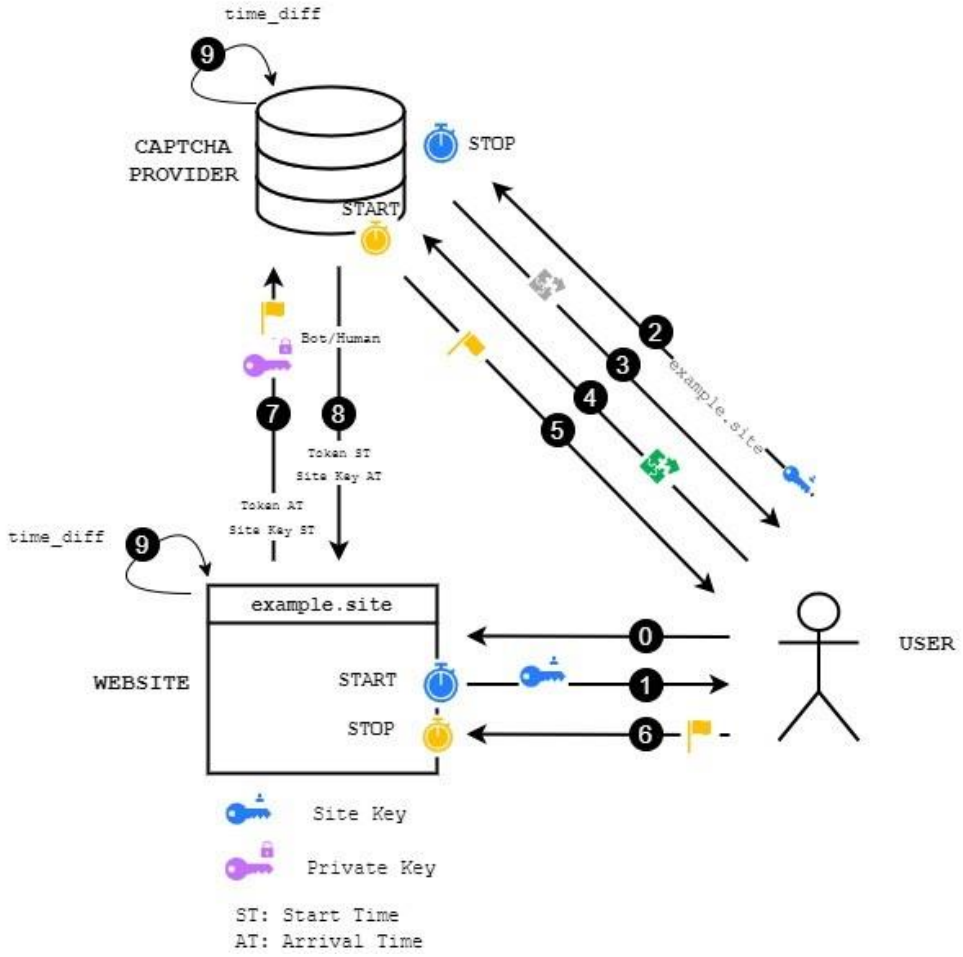
## The problem

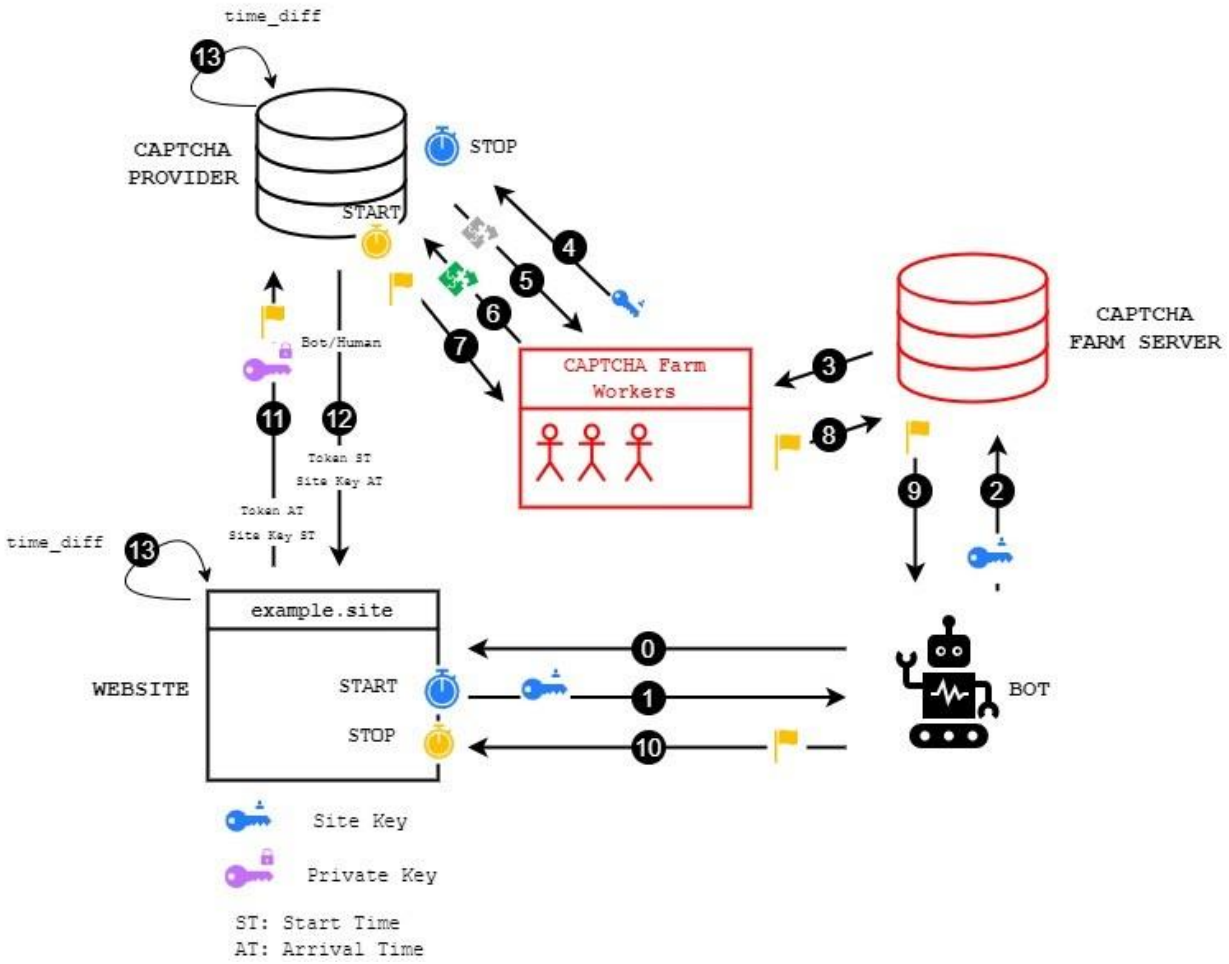


- Due to these farms, CAPTCHA Tests are not an **effective** way to differentiate between human and bots
- CAPTCHA Farms also take advantage of proxies to show the **same IP** and **fingerprint** of the client
- How could we make CAPTCHA Test a **strong mitigation** again?

# Redirection of CAPTCHA tests to CAPTCHA Farms

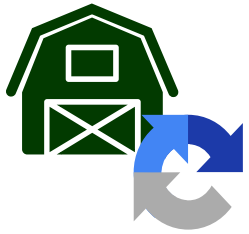
## Our approach



# Redirection of CAPTCHA tests to CAPTCHA Farms

## Our approach



- Site key and token **propagation times** can give an **estimation** of the distance among parties
- We can check if these propagation times are **compatible** with **geographic location** as expressed by the IP of the parties and/or other parameters
  - **Network congestion** need to be taken into account
  - **Possible false positive** for VPNs, VPN IPs whitelisting
- **Stage**
  - POC **Design**

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# Realistic fingerprints fast rotation

## The problem

- The majority of commercial anti-bot solutions are **fingerprint based**
  - **Clustering** bot requests on the same fingerprint/ML model result based on fingerprint and signals
- Nowadays:
  - Bot fingerprints are **difficult to distinguish** from the ones of common real users
  - Sophisticated bots **keep rotating** the fingerprints even when there are not detected already
  - Multiple version of the bot run in **parallel**, one with high volume of traffic, the other ones with low volumes.
    - When the high volume traffic is detected and mitigated, the corresponding version of the bot **stops** its activity and **another version** of the bot **increases the volume** of its traffic
- Detection engine **running constantly** + **analysts' exhaustion**

# Realistic fingerprints fast rotation

## Our approach

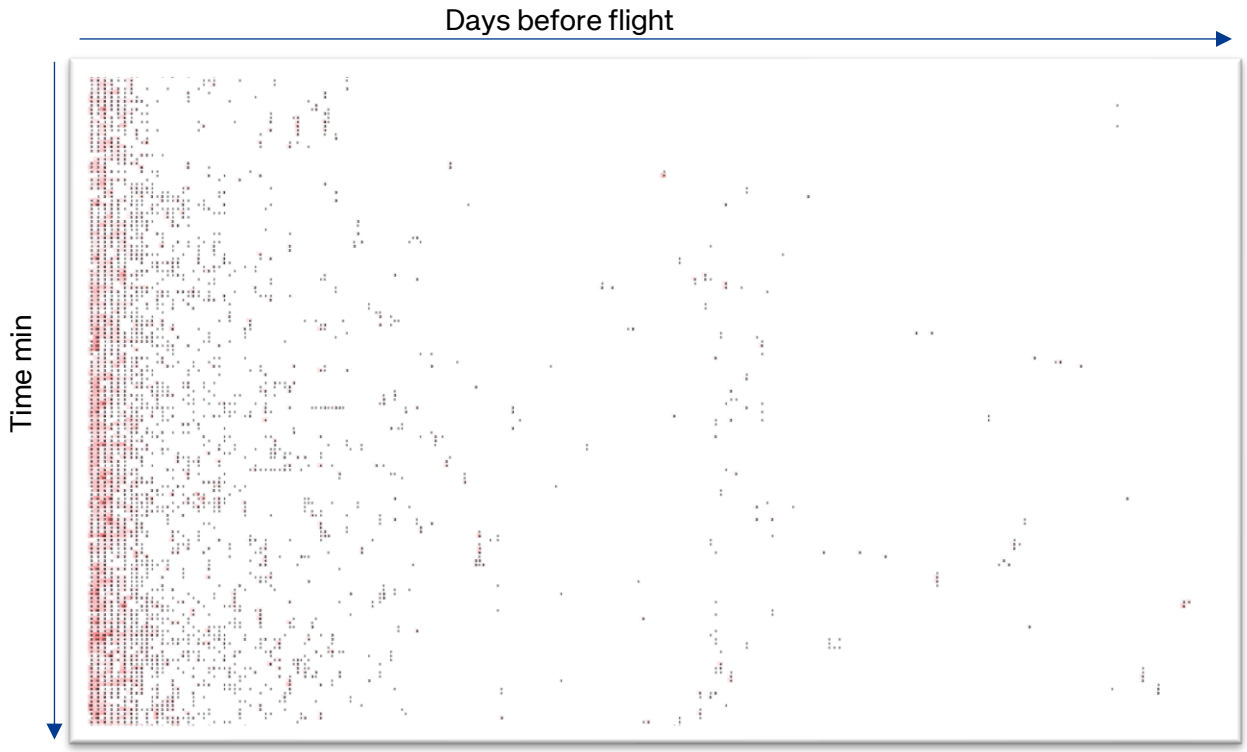
- Bots keep rotating **how technically** they send requests to a website but they will not change **why** they sent those requests
  - Detection based on the interaction on the website and/or requested information

- **Two** approaches under study
  - Bot isolation based on **search patterns**
  - **Graph analysis** of the user interactions

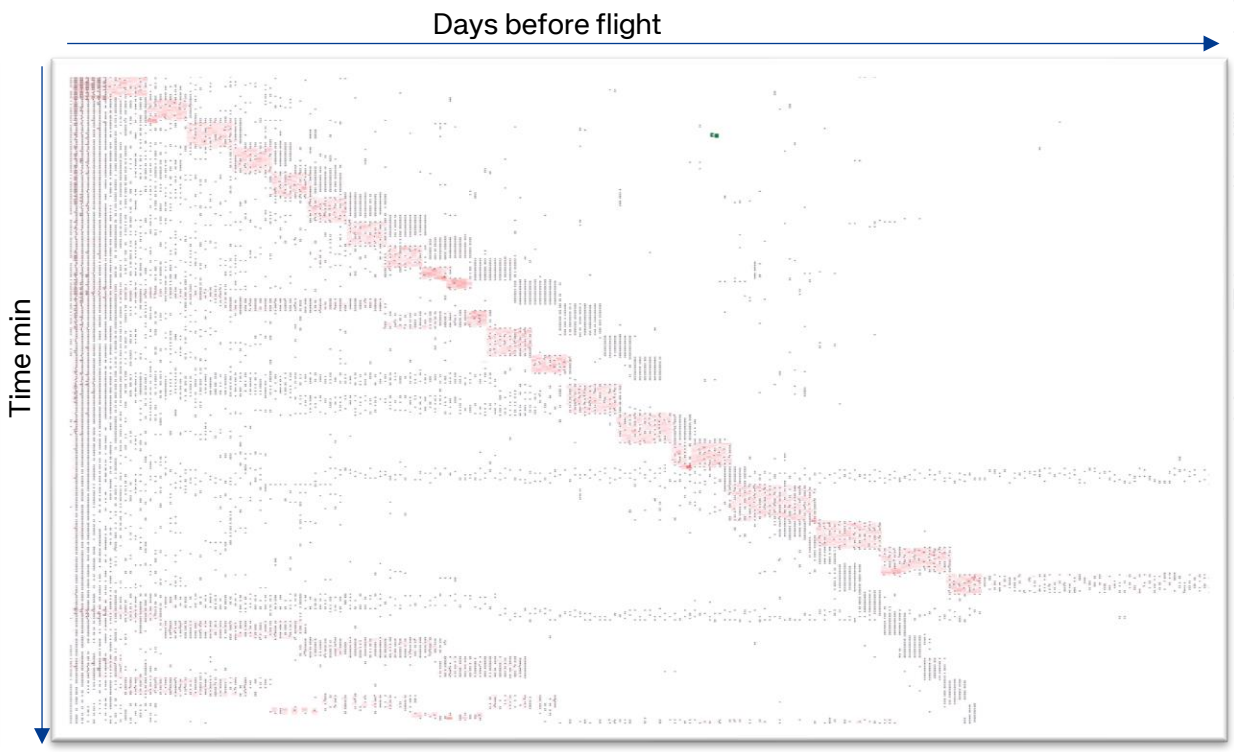
# Realistic fingerprints fast rotation

## Our approach [1/2]

- Bot isolation (also) based on **payload content** that highlight patterns
  - e.g. **Combination** of departure-arrival location and time between the departure date and the date of the search




Normal Traffic




Traffic with bots

# Realistic fingerprints fast rotation

## Our approach [1/2]

- **Advantages**
  - Bots **do not rotate** the parameters of the search
  - **Complementary** to fingerprinting
- **Challenges**
  - Applicable **only** to attacks where there is a search
  - Clearly differentiate real customers from bots to **avoid false positives**
- **Stage**
  - Studying application logs to highlight all possible patterns and **understand the feasibility** of the solution

# Realistic fingerprints fast rotation

## Our approach [2/2]

- **Graph analysis** of the user interaction with the website
  - Graph of all the **possible interaction** on the website
  - **Graph of each user**
  - **Clustering** based on the activity
- **Advantages**
  - Leverage **domain specific knowledge**
  - Detect **attacks** that do not follow under the main ones already considered
- **Stage**
  - **Feasibility** study and initial **testing**

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# Side effects of current mitigation techniques reveal detection

## The problem

- The actors behind the bots can **infer their detection** from the **side effects** of mitigation techniques (blocking, delaying answers,...)
- Once understood they have detected, they **change** approach/fingerprint
- What if we could **prevent them** from knowing they have been detected providing **incorrect but plausible answers**?



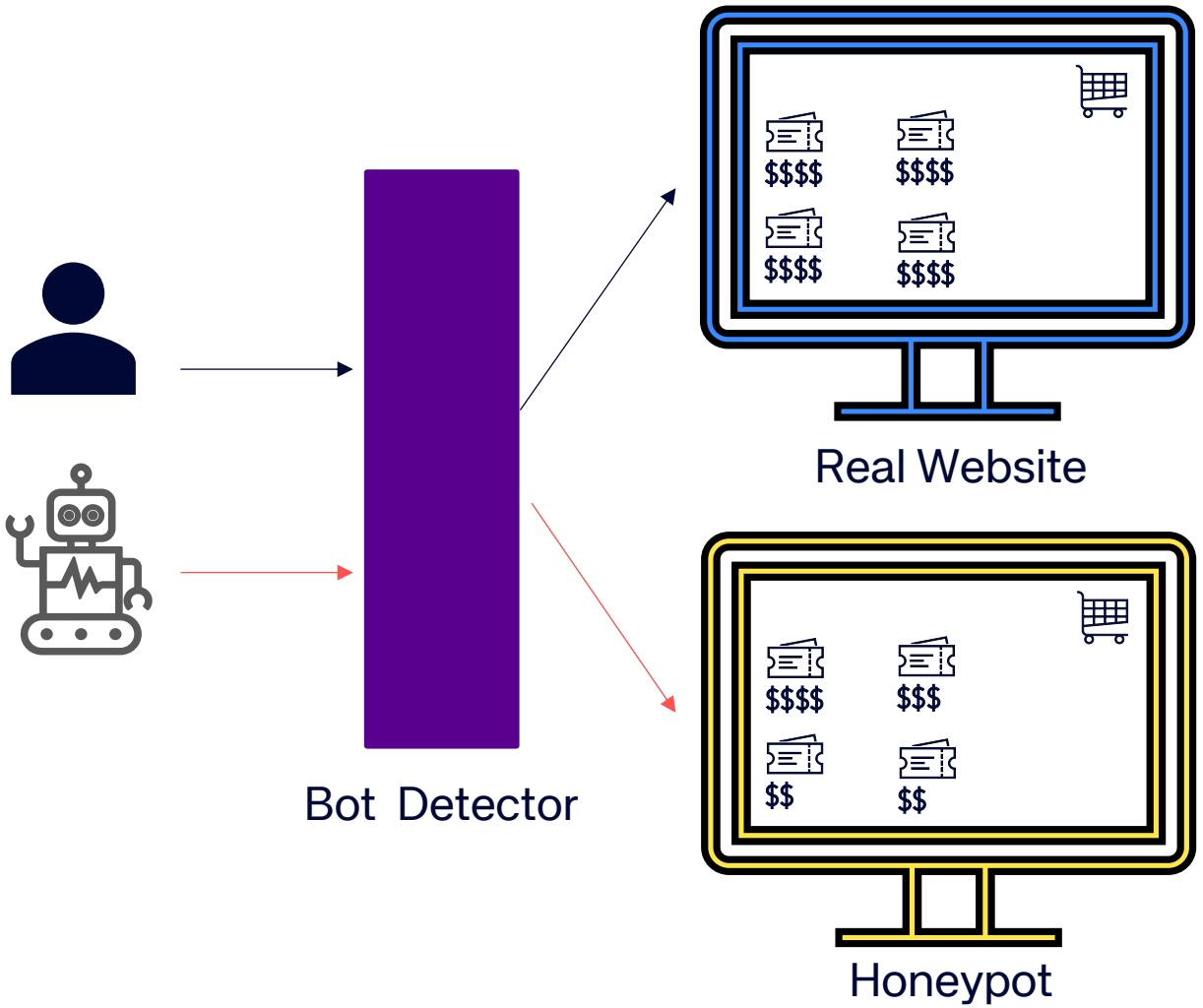


[5] E. Chiapponi (2021). Scraping Airlines Bots: Insights Obtained Studying Honeypot Data. In International Journal of Cyber Forensics and Advanced Threat Investigations.

# Side effects of current mitigation techniques reveal detection

## Our approach

- **Redirection** of detected bots to a honeypot **mimicking the real website**
- **Luring** of the bots that do not have a direct feedback of detection
- Database **poisoning**





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# Honeypot to lure the attackers

- Initial **POC** in 2020
- Collaboration with an airline company, redirection of **specific bot signature**
- Running for **56 days** (interruption linked with COVID-19 restrictions on flights)
- After 3 days from the start of the case study, **modification of fares**: increase the real price by 5% for 10% of the requests
- Amount and timing of the requests **in line** with those before the honeypot
- Bots were **not sophisticated enough** to detect small changes





[5] E. Chiapponi (2021). Scraping Airlines Bots: Insights Obtained Studying Honeypot Data. In International Journal of Cyber Forensics and Advanced Threat Investigations.

# Honeypot to lure the attackers

- **Advantages**
  - **Poisoning** the fare dataset of the attacker
    - **Reduction** of economic incentive in attacks
  - **Increasing** the cost of bot attacks(additional checks to identify honeypot responses)
- **Opportunity**
  - **Expand** the concept to Denial of Inventory attacks
- **Challenges**
  - Fare retrieval and associated **costs**
    - Cache, ML generation, ad-hoc algorithm
- **Stage**
  - Feasibility and **cost assessment**

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# How are we addressing the problems in the current landscape?

- Server-side detection based on **transport layer differences**
- **Study** of the traffic proxied out by the gateways
- /24 **reputation** DB

- CAPTCHA Farm redirection based on **propagation time** of elements exchanged by the involved parties

- Bot isolation based on **search patterns**
- **Graph analysis** of the user interactions with the website

- **Honeypot** reproducing the real website

# Thank you for your attention!

**More questions?**
**elisa.chiapponi@amadeus.com**
**or here in person**

Presentation based on:

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# Backup slides